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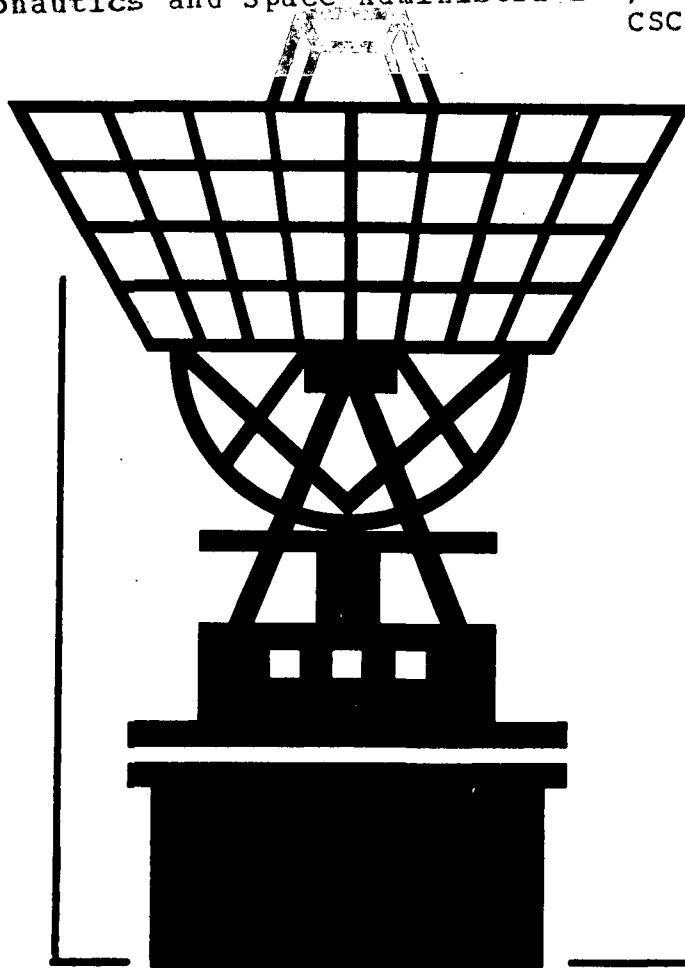
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Office of Space Tracking and Data Systems

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OFFICE OF SPACE TRACKING AND DATA SYSTEMS

The Office of Space Tracking and Data Systems (OSTDS) provides tracking, data acquisition and processing and communications support to all NASA flight projects, including aeronautical research flights, exploratory deep space probes and science and applications missions in Earth orbit conducted by NASA program offices.

Additional support is provided through negotiated agreements with other government agencies such as the Department of Defense (DOD), the National Oceanic and Atmospheric Administration (NOAA) and with space research projects of other countries and international organizations.

Major support functions provided include: tracking to determine position and trajectory of vehicles in space; reception of scientific and engineering telemetry; transmission of commands from ground stations to spacecraft; voice communications with manned spacecraft; and processing of data acquired from space vehicles.

This support is essential to safeguard astronauts' lives during missions; to execute critical commands necessary for survival, navigation and maneuver of automated spacecraft; and to return scientific data from space to Earth. These functions are critical in the chain of events necessary to achieve the scientific objectives of any space flight mission.

TRACKING NETWORKS

A majority of the support provided to flight projects is carried out through facilities of two worldwide tracking networks: the Spaceflight Tracking and Data Network (STDN) and the Deep Space Network (DSN). The STDN is managed by the Goddard Space Flight Center, Greenbelt, Md., and handles all Earth orbital and suborbital missions, both manned and automated. The DSN, managed by NASA's Jet Propulsion Laboratory, Pasadena, Calif., handles planetary and interplanetary missions.

Stations of these networks are linked by a special communications network, the NASA Communications System (NASCOM). This network uses telephone, microwave, undersea cable and satellite links leased from domestic and foreign common carriers to provide instantaneous transmission of data and critical commands among the spacecraft, the tracking stations and the control centers from which the flights are directed.

Control units or complexes at Goddard Center provide mission control functions for all automated Earth-orbital spacecraft. Similar control functions are provided to aeronautical and sounding rocket research flights through facilities at NASA's Dryden Flight Research Center, Edwards, Calif., and Wallops Flight Center, Wallops Island, Va.

In addition to the real time control function, data returned from spacecraft must be provided to participating scientific investigators for detailed analysis. For information from each experiment to be useful to the investigator, it must be separated first from other data and then processed to include indications of time, spacecraft position and orientation and other related parameters. This large scale, general purpose processing is accomplished through centralized facilities under the management of OSTDS.

The networks support some 60 individual flight missions each year, both in Earth orbit and interplanetary space. This heavy, continuing workload includes launch support and occasional tracking and telemetry services to non-NASA missions rendered on a reimbursable basis.

PREPARATIONS FOR UPCOMING MISSIONS

Preparing data processing facilities, ground stations and mission control centers to meet requirements generated by new flight projects is virtually a continuous process. As spacecraft become more capable and complex, OSTDS tasks also increase in scope.

Changes in technology, operational modes and data rates in spacecraft require continuing effort on the ground to insure an appropriate data flow to and from spacecraft in flight. Providing voice communications, command, tracking, telemetry and data processing needed to fulfill mission objectives requires a flexible, adaptable complement of ground support facilities.

Communications capability at STDN stations is being increased significantly to support Orbital Flight Tests (OFT) of Space Shuttle. The data stream to be received from the Orbiter over each station consists of a development flight instrumentation link of 128 kilobits per second (kbps), an operational instrumentation link of 192 kbps and "dumps" of data recorded between station passes at the rate of more than 1 million bits per second.

To provide required real time data for mission control, two additional 56 kbps communications circuits are required at each station. These will feed data directly to the mission control center at NASA's Johnson Space Center, Houston, Texas. Stations will also provide UHF/VHF voice communication during launch and landing, and digital voice reception while in orbit. Radar tracking of the Orbiter will be provided and the command uplink will provide for voice communications in addition to non-voice commands.

WIDEBAND ERA

Providing the vast amounts of data needed to conduct OFTs requires communications bandwidths not available even a few years ago. Only with digital techniques and wideband circuits now provided by the common carriers are such massive real time data transfers possible.

Transfer of data from the receiving point to the control center in real time, without intervening data manipulations, becomes increasingly important with the need for real time operational control. With the advent of Space Shuttle, the increasing complexity and capability of automated satellites and experiment sensors, minute-by-minute direction of a mission with minimal data flow interruptions has virtually become a necessity.

Missions such as Spacelab, with data flows up to 50 million bits per second (mbps) will require even greater bandwidths, coupled with real time operations to speed experiment data to users and scientists.

Flexibility to conduct experiments controlled in real time allows investigators to react quickly to unexpected phenomena, catch transient events or correct errors which otherwise might mean the loss of an experiment. This "adaptive mission" concept allows the greatest scientific return because subsequent operations can take prompt advantage of results observed in earlier experiments. These capabilities will be available for the first time in space missions supported by Tracking and Data Relay Satellite Systems (TDRSS).

TRACKING AND DATA RELAY SATELLITE SYSTEMS

The Tracking and Data Relay Satellite System (TDRSS) is an answer to the need for fast data transmission in ever-increasing amounts. Because of its extremely wide bandwidth, TDRSS will handle Spacelab and similar missions with ease. In addition, TDRSS can provide almost total orbital coverage, rather than merely the current brief coverage during a series of passes over ground stations. Both real time and recorded data presently must be transmitted during widely separated spacecraft passes. The TDRSS mode of operation will permit an approximate sixfold increase in the time available for high-rate data transmissions.

Plans call for operational phases of the Space Shuttle (the Space Transportation System or STS) to be supported by TDRSS. Telemetry data and commands will be relayed directly between the Mission Control Center at Johnson Space Center and the Space Shuttle through TDRSS. The system will provide the nearly continuous communications Shuttle operations will demand. Mission operations can be much more flexible, adjusting promptly to changing conditions and unforeseen problems.

The TDRSS plays a major role in NASA's planning. Besides supporting the Shuttle itself, the system can also provide near-continuous coverage for all low Earth orbiting satellites. A number of tracking facilities in the present Spaceflight Tracking and Data Network can then be eliminated.

In December 1976, NASA awarded a contract to Western Union Space Communications, Inc., a subsidiary of the Western Union Corp., to obtain TDRSS services. Under the contract, the contractor designs, builds and operates the system to provide the required services for a 10-year period beginning in 1980. TRW and Harris, Inc., provide major subcontractor support to Western Union Spacecom, for the spacecraft and ground terminal respectively.

Basically, the TDRSS will consist of four specialized communications satellites in geosynchronous orbit and a ground terminal at White Sands, N.M. One of these satellites will be used by Western Union as a domestic communications satellite and one will be a spare. The remaining two will provide the NASA tracking, command and data relay services.

All TDRSS spacecraft will be launched by the Shuttle with an associated Inertial Upper Stage (IUS) now being developed by the Air Force. Along with Shuttle's additional payload capacity, its design includes redundancy and reliability features not previously available. These advances will reduce the probability of replacement spacecraft being needed to meet the 10-year service requirement.

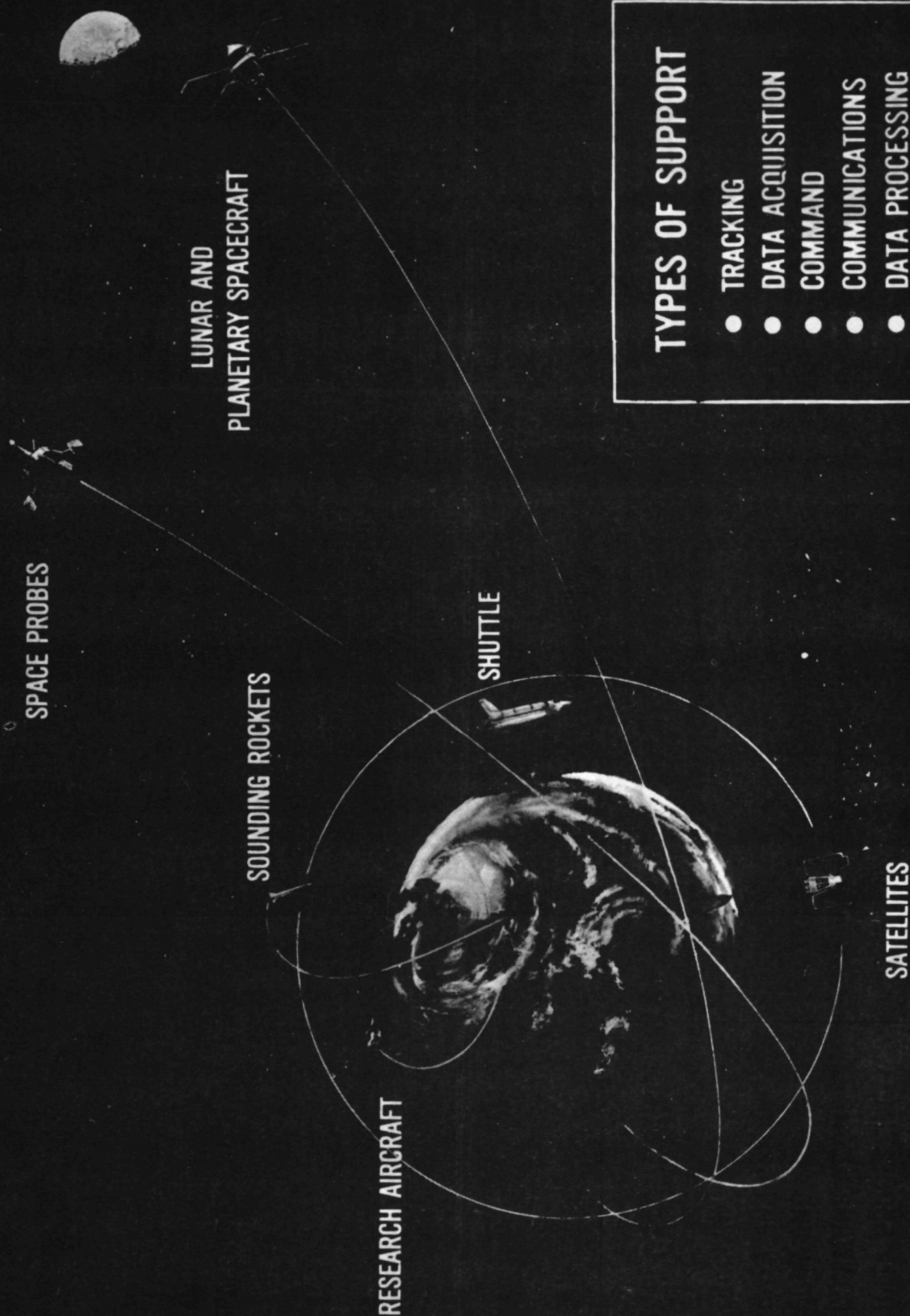
OSTDS MILESTONES

OSTDS support has been a major contributor to many NASA achievements, including:

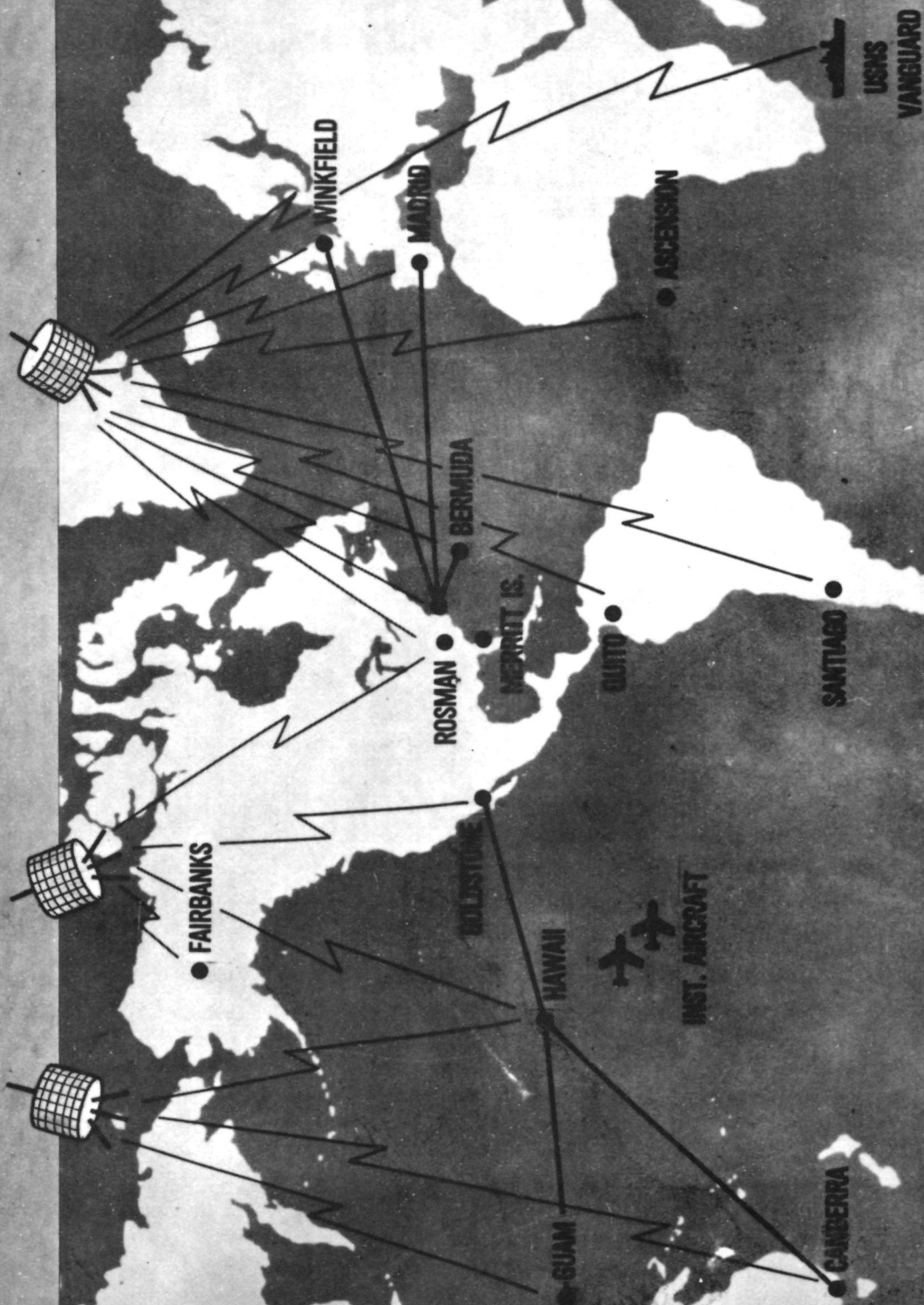
- Successful occultation experiments to test the Einstein theory of relativity, conducted by precise tracking of spacecraft, hundreds of millions of miles from Earth. Einstein's general theory of relativity states that electromagnetic radiation -- in this case the spacecraft radio signal -- passing close to the Sun will be slowed by the Sun's gravitational field.
- Radio astronomy experiments using the mysterious cosmic radio sources known as quasars and pulsars. Large diameter antennas in the NASA network track noise outputs from celestial sources. By recording minute time differences in the arrival of these signals at remote points on the Earth's surface, the precise distance between these remote points can be determined. Over an appreciable period of time, changes in these remote distances indicate shifts in the Earth's surface. These Earth dynamic measurements have been conducted over intercontinental distances (e.g. Goldstone, Calif., to Madrid, Spain) and are valuable in studying Earth surface motions on extended regional and global bases, as distinguished from local motions in the vicinity of a specific fault, e.g., San Andreas.
- Radar mapping of the planet Venus, providing details of the cloud-shrouded planet previously unavailable.

- Successful flybys of the planet Mercury by Mariner 10 -- retrieval of closeup pictures of the planet's surface clearly depicting major landforms such as craters, ridges and plains.
- The Apollo Program -- the first landing by men on the lunar surface, live television transmission of manned lunar exploration events for viewing by millions around the world.
- Earth resources surveys with the Landsat spacecraft -- production of imagery data for use in studies of Earth resource disciplines including agriculture, oceanography, forestry and cartography.
- Flights of many thousands of sounding rockets for scientific studies by U.S. and other world scientists, support of cooperative sounding rocket programs conducted in foreign countries.
- Hundreds of flights of advanced research aircraft -- rocket and jet powered -- support of crosswind landing and other terminal approach and investigations.
- Optical (laser) tracking of geodetic satellites such as Geodynamic Experimental Ocean Satellite (GEOS), leading to important corrections of maps of the Earth's southern hemisphere.

TRACKING & DATA ACQUISITION

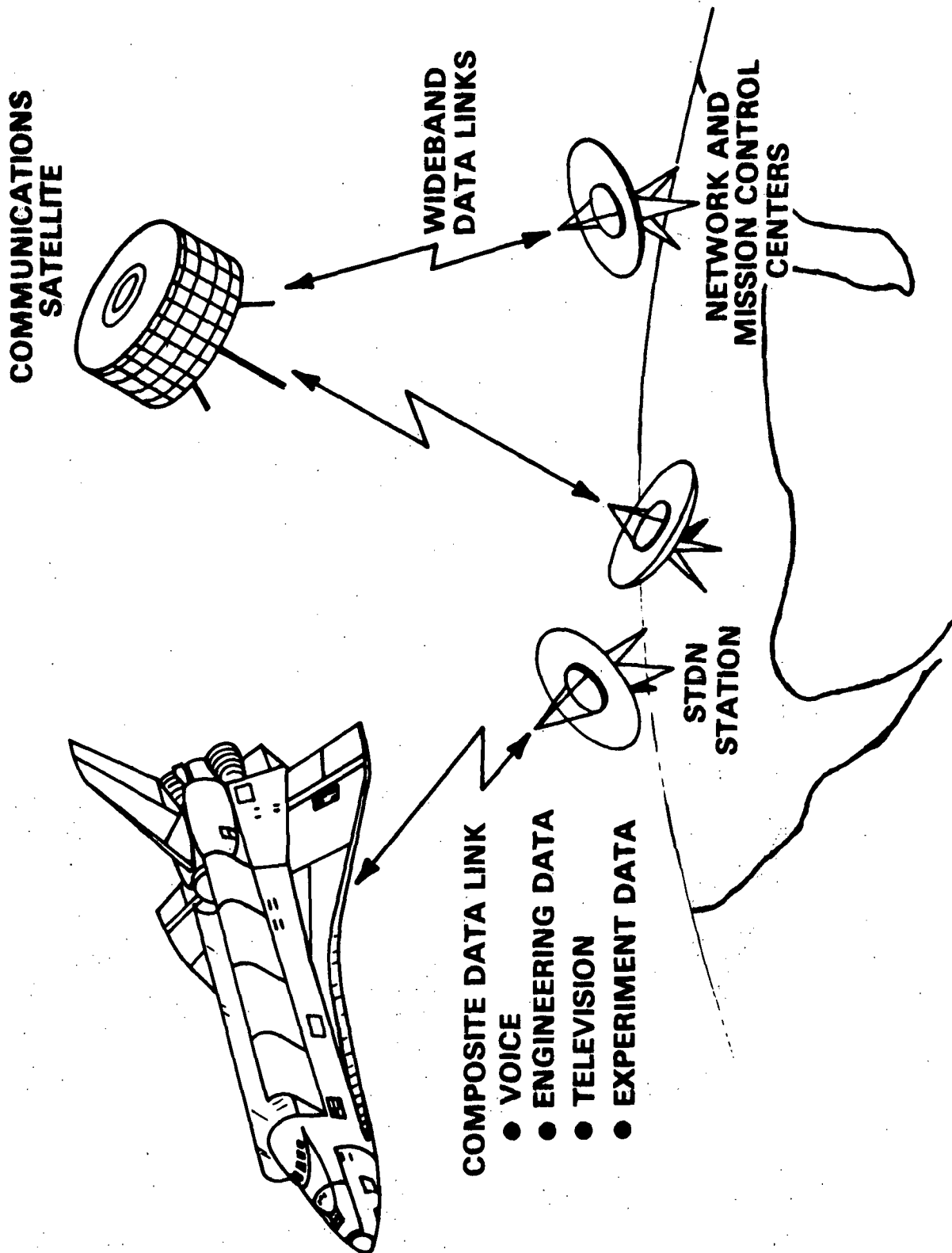


NASA TRACKING, DATA ACQUISITION, AND COMMUNICATIONS NETWORK



SHUTTLE ORBITER FLIGHT TEST (OFT)

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TRACKING AND DATA RELAY SATELLITE

